The *WISE* InfraRed Excesses around Degenerates (WIRED) Survey

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Abstract. The *Wide-field Infrared Survey Explorer* (*WISE*) is a NASA medium class Explorer mission that performed an all sky survey in four infrared bands. We present an overview of the *WISE* InfraRed Excesses around Degenerates (WIRED) Survey, which has the goals of characterizing white dwarf stars in the *WISE* bands, confirming objects known to have infrared excess from past observations, and revealing new examples of white dwarfs with infrared excess that can be attributed to unresolved companions or debris disks. We obtained preliminary *WISE* detections ($S/N > 2$) in at least one band of 405 white dwarfs from the 9316 unique possible targets in the Sloan Digital Sky Survey Data Release 4 Catalog of Spectroscopically Identified White Dwarfs (not all potential targets were available in the sky coverage used here). A companion paper in this volume discusses specific results from our target detections.

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INTRODUCTION

The *Wide-field Infrared Survey Explorer* (*WISE*) is a NASA medium class Explorer mission that was launched on 14 Dec 2009 [1]. *WISE* mapped the entire sky simultaneously in four infrared (IR) bands centered at 3.4, 4.6, 12, and 22 μm (*W1*, *W2*, *W3*, and *W4*, respectively) with 5σ point source sensitivities of approximately 0.08, 0.11, 1, and 6 mJy, respectively. These sensitivities assume a worst-case minimum of eight repeat frames and include the effect of confusion noise. Full sky coverage was achieved in mid-July 2010 but this work utilizes the data available in mid-May 2010.

Prior to the first public release of *WISE* data planned for Spring 2011, a number of early science verification projects are being carried out by the *WISE* Science Team. The *WISE* InfraRed Excesses around Degenerates (WIRED) Survey has the goals of characterizing white dwarf (WD) stars in the *WISE* bands, confirming objects known to have IR excess from past observations (*Spitzer Space Telescope* [2], 2MASS [3], UKIDSS [4], etc.), and revealing new examples of WDs with IR excess that can be attributed to unresolved stellar or sub-stellar companions, or debris disks.

We utilized the Sloan Digital Sky Survey (SDSS) Data Release 4 (DR4) Catalog of Spectroscopically Identified White Dwarfs [5]. The final version of this project will draw targets from the SDSS DR7 WD catalog [6], as well as a separate sample from the McCook & Sion White Dwarf Catalog [7]. We will also compare the *WISE* photometry for known WDs with dust to published IR photometry (e.g., from *Spitzer*) to explore

TABLE 1. WIRED Survey Preliminary Detection Statistics

Category	Number of Detected Targets: $f_\nu > 5\sigma$ Sensitivity	S/N > 5	S/N > 2
W1 (3.4 μm) only	335	400	405
W2 (4.6 μm) only	224	274	405
W3 (12 μm) only	3	3	54
W4 (22 μm) only	0	0	28
Of the targets with *W1* and *W2*...			
Classified as single WD	28	46	120
Classified as WD + M binary	190	224	284
Known WD + dust disk (GD40)	1	1	1

the possibility of variability in their emission. We present here an overview of the characteristics of these WDs in the *WISE* bands. A companion paper in this volume discusses specific results from our target detections [8].

PRELIMINARY WIRED SURVEY RESULTS

With the initial 20% sky coverage available in mid-May 2010, we obtained preliminary *WISE* detections (S/N > 2) in at least one band of 405 WDs from the 9316 unique possible targets in the SDSS DR4 list (not all potential targets were available in the sky coverage used here). A breakdown of our detection results, based on the preliminary *WISE* profile fitting photometry, is given in Table 1. The 5σ sensitivity level refers to the values listed in the Introduction, which are conservative and underestimate the true sensitivity for targets with > 8 redundant frames on the sky and/or in locally unconfused regions. The S/N criteria utilize the calculated S/N values for the *WISE* profile fitting photometry. Many of the targets were detected because they are known WD+M star binaries and, hence, are brighter than the WD alone in the IR. Although we utilize only the *W1* and *W2* data for the remainder of this paper, we note that *W3* could potentially provide a sensitive diagnostic test for the presence of the 10 μm silicate emission that typically goes hand-in-hand with the presence of dust in WDs (e.g., [9]).

Figure 1 shows histograms of the number of detected targets as a function of magnitude, using the S/N criteria described above for Table 1. Based on the magnitude beyond which the number of detections begins to decrease, the *W1* sample is likely complete down to the stated 5σ sensitivity limit, while the complete *W2* detections might extend to slightly fainter magnitudes, at the level of the S/N $\approx$ 5 detections.

Figure 2 shows several color-color diagrams for the detected targets. There is a distinct separation between the loci of known single WDs and known WD+M star binaries. This separation shrinks from *r*-band to *J*-band when compared against *W1* and *W2*. The known dusty WDs are especially distinctive in the *J*-band diagram. However, the two WIRED Survey candidates shown in Figure 2, both of which lie near the edge of color loci in all three diagrams, are not located near the known dusty WDs in the *J*-band diagram. For example, SDSS122859.2+1040033.0 (henceforth, SDSS1228; square

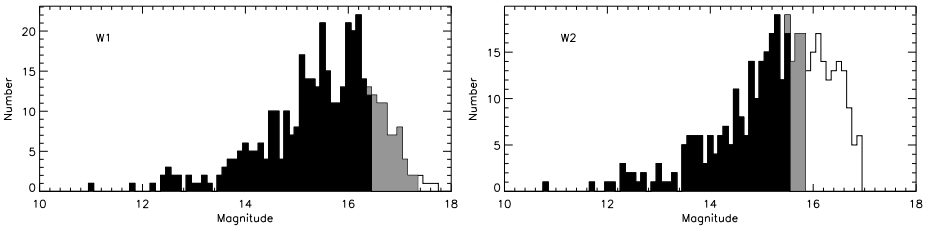

FIGURE 1. Number of detected WDs as a function of magnitude in the *WISE W1* (left) and *W2* (right) bands. The black area shows photometry brighter than the 5σ sensitivity levels, while the grey and white areas show the histogram extensions for photometry with $S/N > 5$ and > 2, respectively (see Table 1).

point at $W1-W2 = +0.85$ in the J-band diagram) has a similar ($W1-W2$) color as our WIRED2 WD+disk candidate (circle point at $W1-W2 = +0.92$ in the J-band diagram). Yet, they have very different ($J-W1$) colors. The position of SDSS1228 in the color-color diagram is very distinctive, whereas the position of WIRED2, although near the edge of the single WD color locus, is consistent with the colors of a single WD.

The difference between SDSS1228 and WIRED2 stems from both the wavelength at which the IR excess due to dust is first visible and the amount of IR excess. In the case of SDSS1228, the excess is already noticeable at H-band and is quite bright: after subtracting the WD contribution, the IR excess by itself is a factor of ≈ 4 brighter than the WD alone in the *W1* band [10]. On the other hand, the excess in WIRED2 is first noticeable at *W1*, and is a factor of only ≈ 1.5 brighter than the WD alone in *W1*. Similarly, SDSS1228 has about the same brightness in both *W1* and J, whereas WIRED2 is about 40% *fainter* in *W1* than in J. These factors conspire to make the position of WIRED2 in the color-color diagram less distinctive than that of SDSS1228. A reliable detection of the IR excess in WIRED2 comes from examining its spectral energy distribution from the optical out to the mid-IR *WISE* photometry, and this is the strategy that will be utilized for the WIRED Survey.

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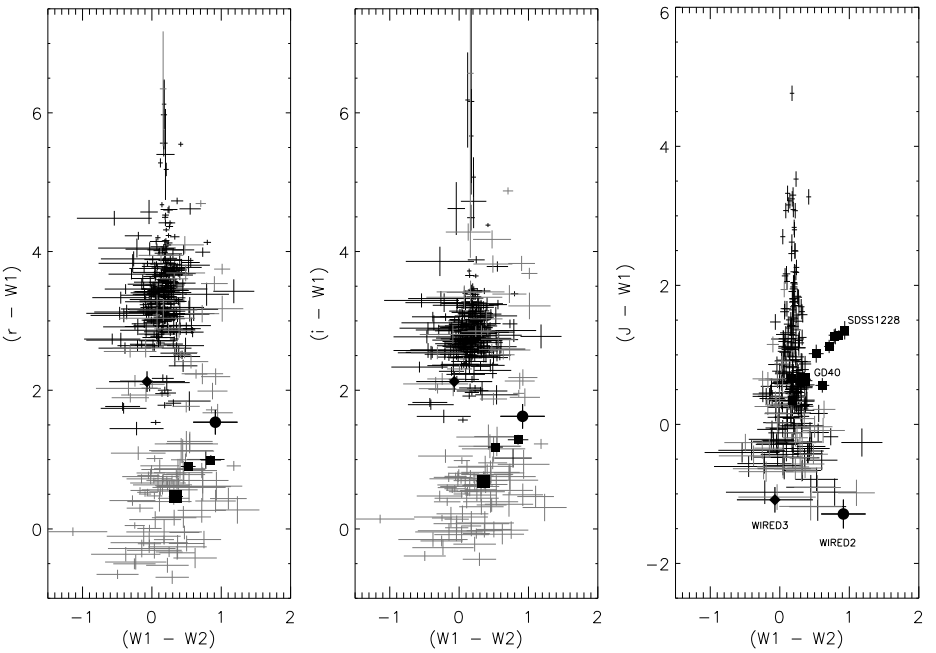

FIGURE 2. Color-color diagrams for detected targets, constructed using photometry in the *WISE W1* and *W2* bands, with SDSS *r* (left), SDSS *i* (middle), and *J* (right). The *J* data are from UKIDSS; 2MASS was used (transformed to the UKIDSS system; [11]) when no UKIDSS value was available. The *WISE* data are profile-fitting photometry with $S/N > 5$ in *W1* and $S/N > 2$ in *W2*. Data points at color index values $> +4.5$ on the vertical axis in each plot are possibly spurious, resulting from target mismatches between surveys or the preliminary nature of the *WISE* photometry – these will be resolved in the final WIRED Survey results. The data include: known single WDs (light error bars), known WD+M binaries (dark error bars), known WD+disk systems (squares), and new WD+disk (WIRED2; circle) and WD+L5 (WIRED3; diamond) candidates. Only one known WD+disk (GD40; large square) was contained in the mid-May *WISE* data. For illustrative purposes, we extracted *WISE* photometry for several other WD+disk systems from the (now) full sky coverage.

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